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Request for grant of a Patent

Form 1/77

Patents Act 1977

❶ Title of invention

1 Please give the title of the invention

RADIATION SHIELD

❷ Applicant's details

❑ **First or only applicant**

2a If you are applying as a corporate body please give:

Corporate name

Country *(and State of incorporation, if appropriate)*

2b If you are applying as an individual or one of a partnership please give in full:

Surname HARE

Forenames John Thomas

2c **In all cases**, please give the following details:

Address 70 High Burn
Stonelaw Grange
Cramlington
Northumberland

UK postcode *(if applicable)*

Country England

ADP number *(if known)* 0242150100103

2d, 2e and 2f: If there are further applicants please provide details on a separate sheet of paper.

Second applicant *(if any)*

2d If you are applying as a corporate body please give:

Corporate name

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2e If you are applying as an individual or one of a partnership please give in full:

Surname WEIR

Forenames Donald

2f **In all cases**, please give the following details:

Address 15 Archery Rise
Nevilles Cross
Durham

UK postcode *(if applicable)* DH1 4LA

Country England

ADP number *(if known)* 06.519800.1

An address for service in the United Kingdom must be supplied

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R 10/1/95

Mathys & Squire
100 Grays Inn Road
LONDON
WC1X 8AL

Address for service details

3a Have you appointed an agent to deal with your application?

Yes [X] No [ ] ***go to 3b***

please give details below

Agent's name MATHYS & SQUIRE

Agent's address ~~10 Fleet Street~~
~~London~~

Postcode ~~EC4Y 1AY~~

Agent's ADP number ~~1081001~~

3b: If you have appointed an agent, all correspondence concerning your application will be sent to the agent's United Kingdom address.

3b If you have not appointed an agent please give a name and address in the United Kingdom to which all correspondence will be sent:

Name

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❹ Reference number

4 Agent's or applicant's reference number *(if applicable)* JADC/BMM/17937

❺ Claiming an earlier application date

5 Are you claiming that this application be treated as having been filed on the date of filing of an earlier application?

Please mark correct box

Yes ☐ No ☒ ➡ ***go to 6***

↓ ***please give details below***

❑ number of earlier application or patent number

❑ filing date

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15(4) (Divisional) ☐ 8(3) ☐ 12(6) ☐ 37(4) ☐

❻ Declaration of priority

❻ *If you are declaring priority from a PCT Application please enter 'PCT' as the country and enter the country code (for example, GB) as part of the application number.*

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❼ Inventorship

7 Are you (the applicant or applicants) the sole inventor or the joint inventors?

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❽ Please supply duplicates of claim(s), abstract, description and drawing(s).

❽ Checklist

8a Please fill in the number of sheets for each of the following types of document contained in this application.

Continuation sheets for this Patents Form 1/77			
Claim(s)	2	Description	13
Abstract		Drawing(s)	2

Please mark correct box(es)

8b Which of the following documents also accompanies the application?

Priority documents *(please state how many)*	—
Translation(s) of Priority documents *(please state how many)*	—
Patents Form 7/77 – Statement of Inventorship and Right to Grant *(please state how many)*	—
Patents Form 9/77 – Preliminary Examination/Search	X
Patents Form 10/77 – Request for Substantive Examination	—

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RADIATION SHIELD

This invention relates to radiation shielding material primarily intended for shielding sources of high energy radiation, e.g. gamma rays, such as are found in association with nuclear-powered steam raising installations and the like.

In such installations, ancillary equipment and apparatus such as valves, pumps and pipes of the steam generating circuit, located in areas to which human access may be required, e.g. for routine maintenance, overall and repairs, can become contaminated with radiation and it is therefore desirable to provide shielding to protect the operatives who have to enter and work in it. There are also many other working environments in which such shielding is desirable, e.g. in hospitals and in experimental laboratories employing machinery generating gamma rays or other radiation such as X-rays.

Many proposals have been made hitherto for providing this shielding. One involves lead sheet which is hung from overhead fixings or draped over the parts to be shielded but its use is restricted because of its weight, its lack of flexibility and its unsuitability where direct contact with metal parts, which are usually made of stainless steel, is required. Other proposals are centred on sheets of plastics materials filled with particles of lead or other radiation-screening materials, optionally laminated to other layers which are variously of fabric, plastics-coated fabric, and plastics which may be reinforced e.g. with fabric, or combinations of these. Such materials are described, for example, in GB-A-670325, 680715, 703153, 851479, 954594, 1122766 and 2118410, EP-A-0117884 and US-A-3622432 and 5001354.

While such sheeting is suitable for many purposes, there are locations where its use is not acceptable, e.g. because it is cumbersome or it takes up too much room or there are no convenient fixings for it and no other means for supporting it. Moreover, the shielding of some fittings, such as pipe T–pieces, is not readily achieved using sheet material.

The present invention is designed to resolve these shortcomings.

According to the present invention, there is provided a moulded shield for a source of radiation said shield defining a cavity to receive said source, and including a layer of polymer loaded with particulate radiation–shielding material adapted to surround a radiation source located in said cavity. The shield may comprise a single part or a plurality of separate cooperating parts which together define the cavity.

While it can be envisaged that for some applications, e.g. for shielding a radiation source without touching it, the part or parts forming the shield may be made of the loaded polymer, in general it will be found that for the loading level required to achieve adequate shielding within an acceptable thickness of material, some physical properties of the loaded polymer, e.g. its strength and its ability to support its own weight, may be inadequate. Thus, in accordance with a preferred embodiment of the invention, the shield comprises a core layer of said loaded polymer adapted to surround a radiation source located in said cavity, said core layer being located between two outer layers of solid polymeric material. Still more preferably, the core layer is encapsulated in said solid polymeric material.

Where the shield is formed of a plurality of parts which together define the cavity, it will be understood that each part may comprise a core layer between two outer layers of, or encapsulated in, said solid polymeric material.

The invention will now be described in more detail with reference to preferred embodiments and with the aid of the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a shield in the form of a split tube for fitting over a pipe;

Figure 2 is a cross–section through an alternative embodiment to the tube of Figure 1;

Figure 3 is a cross–section through an alternative to the tube of Figure 2;

Figure 4 is a cross–section through a shield for a pipe provided by two concentric split tubes of the kind illustrated in Figure 1;

Figure 5 is a perspective view of a two–part moulded shield intended to fit over a pipeline T–piece;

Figure 6 is an exploded view of an enlarged cross–section through one arm of the moulding of Figure 5; and

Figure 7 is a perspective view of another moulding according to the invention.

Depending on the nature of the radiation source and the shape of the piece of equipment to be shielded, the shield may comprise a single moulding or a plurality of separate cooperating parts which together define the cavity and enclose the radiation source.

For example, for protecting pipes, the shield may be in the form of a tube 2 (Figure 1) with a longitudinal slit 4 and may be made of resilient material enabling the tube to be opened along the slit, pushed over a length of pipe and then closed over the pipe, e.g. by the use of quick–locking plastics straps of the well known kind such as used as ties in horticulture. In one preferred embodiment, the tube is flexible so that it may accommodate curves and bends in pipes.

To reduce or eliminate shine, the slit is preferably so formed that when the tube is closed over the pipe, the protection provided by the tube is unbroken. For example, the slit 4 may extend from the inner face to the outer face of the tube at an angle to the radius (Figure 2). An alternative, wherein the slit is in the form of a double–crank, or dog–leg, is shown in Figure 3. Alternatively, as illustrated in Figure 4, a second split tube 6 may enclose the first, with the slit 8 located at a different circumferential position to the slit 4 of the first tube 2. Thus, in this embodiment, the shield comprises the pair of split tubes.

As stated above, the shield may comprise a plurality of separate moulded parts which together define a cavity to enclose the radiation source. Thus, for example, it will also be apparent that if desired, the shield for a pipe length may be formed from a two–part moulding wherein each part has a longitudinally extending cavity which is generally semi–circular in cross–section, the parts fitting together to enclose the pipe.

By way of further example, a two–part moulding suitable for enclosing a pipe T–piece is illustrated in Figures 5 and 6. The moulding comprises two parts designed to mate along the plane of the axes of the T–joint and each part 10, 20, is thus, in plan, in the form of a

T and contains a pipe–receiving cavity 12,22 which is generally semi–circular in cross–section. The parts are so designed as to overlap when placed together in order to reduce or eliminate shine. Thus, in the embodiment illustrated in Figures 5 and 6, the face 14 of the part 10 which is intended to mate with the face 24 of the part 20 to form the cavity of the pipe T piece is provided along each of its longitudinal edges with a cut–away step portion 16 which receives a lug 18 formed along the corresponding longitudinal edge of the mating face of the part 20.

Other means of eliminating shine will be apparent to those skilled in the art. For example, clips 30 (Figure 7) may be provided for fitting over the two parts which enclose the T–piece, to cover the joints between the parts, and which are themselves mouldings according to the invention.

As indicated above, the shield, or the parts forming the shield, may be formed of a composition comprising polymer loaded with particles of radiation screening material. Preferably, however, and as illustrated in Figure 2, the shield comprises a core layer which is represented in the drawing by the shaded area 30, of polymer loaded with particulate radiation shielding material adapted to surround the radiation source located in the cavity, the core layer being located between two layers 40 of solid polymeric material. In the embodiment illustrated, the core layer is actually encapsulated within the solid polymeric material which, as shown, completely surrounds the core 30. Where the shield is formed of several parts, the core layer of each part is so formed that when the parts are assembled to form the shield, a core layer is provided which substantially surrounds the radiation source located in the cavity defined by the shield. It will be understood that when the

core layer of each part is encapsulated in solid polymeric material, there will be small areas around the cavity unprotected by the core layer but this can be rectified by providi. a further part and locating it so that its core layer covers the area in question. Alternatively, and preferably, the parts are constructed and arranged to fit together with overlap.

While any suitable material may be employed for the polymer of the core and the solid polymeric material of the outer layers, where used, manufacture is considerably simplified if a curable liquid resin is employed, especially one which is curable at room temperature or only moderately elevated temperatures. Alternatively, fusible particulate material, e.g. powdered plasticised PVC, may be employed; however this requires relatively high temperatures to effect fusion and pressure may also be required.

For many applications, and especially those wherein the shields are likely to come in contact with stainless steel, it is preferred that the inner surface or surfaces of the shield be free of metallic components that may form an electrolytic cell with the steel and that the solid polymeric material employed for the skin of the moulding be substantially free of halide and sulphide. Likewise, where the shields are to be employed in confined spaces, it is preferred that they are free or substantially free of components which may give rise to toxic fumes on combustion, e.g. nitrogen– or phosphorus–containing species. It is also desirable for the mould surfaces to be substantially non–wettable by water since this assists cleansing in the event of accidental contamination. For these and other reasons, one particularly preferred material for the outer layers is silicone elastomer, especially the grade employed for the manufacture of moulds. This material not only has acceptably low

levels of chloride, sulphide and nitrogen but also exhibits a desirable combination of physical properties, especially tear strength, flexural strength and Shore hardness. It is also readily moldable into complex shapes using inexpensive moulds and uncomplicated procedures, and without the need for pressure or more than mildly elevated temperatures. In some cases curing can be achieved at room temperature although it may be desirable to apply heat to accelerate the cure.

For less critical uses, other casting materials which may be employed include, for example, castable polyurethanes, polyesters, epoxies and phenolics.

Of course, it is not essential that the outer layers are formed of the same material; the layer forming the inner surface of the shield may be of a different material to that forming the outer surface.

The choice of material for the loaded polymer is less critical where it is employed as a core material provided it bonds well to and is compatible with the solid polymeric material employed for the outer layers, and is inert to the radiation–screening material employed. Examples include polyolefins, polyamides, polyesters, vinyl polymers, polyurethanes and the like. However, in general it is preferred that the polymer used for the core material and that (or those) used for the outer layers are of the same chemical nature since this ensures compatibility and reduces the possibility of failure along a joint between the core and an outer layer. For this reason, it is preferred to use silicone for the core when the outer layers also comprise silicone.

While any suitable particulate radiation–screening material may be used provided the particles can be incorporated in the chosen plastics material and do not adversely affect it, e.g. are inert to it, the preferred material is lead. In general, it will be preferred to include as high a proportion of the radiation screening material in the core as possible consistent with obtaining a coherent product. In general, however, the limiting factor is the volume of particles that can be mixed into the polymer. For lead particles and silicone elastomer, a preferred concentration of the particles is in the range 50 to 95% by weight, more preferably 75 to 95% based on total weight of lead particles and silicone. Below 50%, the radiation protection per unit volume of the moulding is poor and above 95% there is difficulty in incorporating the particles into the silicone. Other radiation–screening materials and/or other polymeric materials may lead to different ranges of optimum concentration but these can readily be determined by simple experiment.

It will be understood that the radiation–shielding efficiency of the shield will depend *inter alia* on the concentration of radiation–shielding particles in the loaded polymer layer and its thickness. It is therefore desirable to make the core as thick as possible relative to the total thickness of the moulding, and to minimise the thickness of the outer layers commensurate with providing the desired properties in the laminate. As indicated above, in some applications it may be possible to eliminate the outer layers entirely but for most applications it will be found desirable to include outer layers and in general, we have found that thicknesses as small as 1 to 2mm are adequate for these outer layers and even thinner layers may be satisfactory in some cases. Of course, thicker layers may also be used but little additional advantage is likely to be gained thereby.

The overall thickness of the shield is controlled by the desired level of radiation protection on the one hand and weight or volume, or both, on the other. Preferred thicknesses of the loaded polymer layer are in the range 5 to 20mm, more preferably 8 to 16mm.

The moulded shields of the invention may be rigid or flexible and the choice will depend to some extent on the intended use. Thus, for example, it may be preferred for tubes intended to cover pipes to be flexible so as to accommodate curves and bends. However, other mouldings, e.g. to cover pipeline T pieces, may desirably be substantially rigid. The materials for the core (and outer layers where used) should be chosen with the flexibility or rigidity desired for the moulding in mind. Alternatively, an otherwise flexible moulding such as would be obtained from the use of silicone elastomer in the core and outer layers, may be rigidified by incorporating a rigid form, e.g. metal plate, in the moulding.

The mouldings of the invention, or each part thereof where the moulding comprises a plurality of parts, may be produced by filling a suitably shaped mould with a preformed mixture of the polymer and radiation–screening particles and causing or allowing the polymer to set. Where the loaded polymer forms the core of the moulding, the moulding may be formed by coating the outer walls of the mould with the polymeric material intended to form the outer layers, thereafter depositing the core material and then applying a further layer of the polymeric material. With the preferred choice of silicone elastomer, for example, the walls of the mould are first coated with curable silicone liquid. For non–horizontal surfaces, a thixotropic liquid may be employed. The coating is then caused or allowed to partially cure until it is no longer fluid but is noticeably tacky. The core

composition is then located within the coated walls of the mould e.g. by forming a pourable composition of the radiation–screening particles and the chosen polymer, e.g. silicone, and pouring the composition into the mould until the desired thickness is obtained. This core material is then caused or allowed to partially set so that it is no longer fluid. Thereafter a layer of the curable silicone liquid is applied over the core material and either levelled to the top of the mould or alternatively a lid is applied to the mould and any excess of the liquid is removed. The whole is then caused or allowed to fully cure, e.g. by application of heat.

If desired, other layers may be included in the moulding, e.g. between the core layer and one or both of outer layers (where used) and/or over one or more surfaces of the moulding, to modify its physical and/or surface properties.

Fillers and/or other additives other than the radiation–screening particles may be included in the loaded polymer, if desired, and the outer layers (where used) may also include fillers or other additives, e.g. pigments. It may even be acceptable to include small quantities of radiation–shielding particles in an outer layer; however this is not advisable where the layer is intended to come into contact with the equipment it is shielding where that equipment is metallic, especially stainless steel.

Reinforcement, e.g. in the form of fibrous material, e.g. carbon or glass fibre, may be included in the moulding e.g. as chopped fibres, rovings or woven or unwoven webs.

A particular and very important advantage of the invention is that as the shields may be specifically designed and manufactured to fit over and enclose particular shapes of varying sizes and degrees of complexity, the shielding can be designed specifically for a particular apparatus in a particular location and the subsequent application of the shielding to that apparatus can be achieved much more speedily than by the conventional method of draping and hanging sheets or erecting or fabricating housings on site from simple shapes such as sheets and tiles.

The invention is now illustrated by the following Example in which all parts are by weight.

EXAMPLE

100 parts of the base component of the silicone elastomer system marketed by Dow Corning as Silastic E, 1.09 parts of yellow pigment (WS 15414A from West and Senior Ltd. of Manchester, England), 10 parts of curing agent for the base and 0.14 part of amorphous silica as a thixotropic agent were mixed together, the resultant mixture was used to coat the walls of a mould designed to produce the moulding 10 of Figures 5 and 6, with a 1–2mm coating of the material, and the mould was heated to partially cure this coating. The mould was dimensioned to produce a moulding 10 having the cross–section as shown in Figure 6 wherein the dimension AB is 75mm, the dimensions AC, BD, EF and GH are each 15mm, and the dimensions CE and DG are 5mm. JK is 40mm and thus LM is 10mm. The mould was constructed and oriented so that the face AB of the resultant moulding was at the top.

The composition for the core was formed by mixing together 100 parts of the same silicone base, 10 parts of curing agent and 885.5 parts of 80–200 mesh lead particles and this composition was poured into the coated mould to fill the mould to within about 1–2mm of the top. The mould was then heated again to partially cure this layer.

Finally, more of the first composition was poured over the partially cured core layer, sufficient being used to complete the filling of the mould and provide a layer about 1–2mm thick, any excess being removed by doctor knife. The mould was then heated to cure the top layer and complete the curing of the first applied material and the core layer. The resultant moulding was then removed from the mould.

In similar fashion, a moulding 20 was formed having the dimensions (referring again to Figure 6) of AB=75mm; AP=BQ=45mm; RS=TU=15mm; PR=TQ=5mm; VW=40mm and thus XY is 10mm. The mould was oriented so that the face AB of the moulding was at the top.

To assess the attenuation of the moulding, an approximately 9–10mm thick tile of material was formed having a 6mm core of the same material as the core of the moulding between two outer layers, each 1–2mm thick, of the same material as the outer layers of the moulding. The attenuation of the tile was measured using an iridium 192 isotope and found to be equivalent to about 5–5.5mm of lead, however, the weight of the tile is less than half the weight of a corresponding tile made from 5.5mm lead. Using an RO2 radiation dose meter with a 37GBq Cs 137 source, the attenuation at a dose rate of 370

micro Sv/hr was found to be 28.3%. The attenuation of a collimated Co 60 source of mean energy 1.25 MeV was measured at 21% at dose rates of 500μGyh^{-1} and 50μGyh^{-1}.

A sample of the outer skin of the moulding was analysed for fluorine, chlorine and sulphur and found to contain 67.7, 24.05 and 73.3mg/kg, respectively. The nitrogen content of the moulding was negligible.

CLAIMS

1. A moulded shield for a source of radiation said shield defining a cavity to receive said source and including a layer of polymer loaded with particulate radiation–shielding material adapted to surround a radiation source located in said cavity.

2. A shield as claimed in claim 1 wherein the polymer loaded with radiation–shielding material is a cured liquid resin.

3. A shield as claimed in claim 2 wherein the cured liquid resin is silicone.

4. A shield as claimed in any one of claims 1 to 3 wherein the particulate radiation shielding material comprises lead particles.

5. A shield as claimed in any one of claims 1 to 4 wherein the moulding comprises a core layer of the loaded polymer located between two outer layers of solid polymeric material.

6. A shield as claimed in claim 5 in which the core is encapsulated in said solid polymeric material.

7. A shield as claimed in claim 5 or claim 6 wherein the solid polymeric material comprises cured liquid resin.

8. A shield as claimed in claim 7 wherein the solid polymeric material comprises silicone.

9. A shield as claimed in any one of claims 1 to 8 in the form of a tube with a longitudinal slit, for fitting over a pipe.

10. A shield as claimed in claim 9 wherein the slit is so formed as to prevent shine.

11. A shield as claimed in any one of claims 1 to 8, comprising a plurality of separate cooperating parts which together define the cavity.

12. A shield as claimed in claim 11 comprising a pair of cooperating parts which fit together to provide a cavity for a pipeline T–junction.

13. A shield as claimed in claim 11 or claim 12 wherein the parts overlap when fitted together to enclose the cavity, to prevent shine.

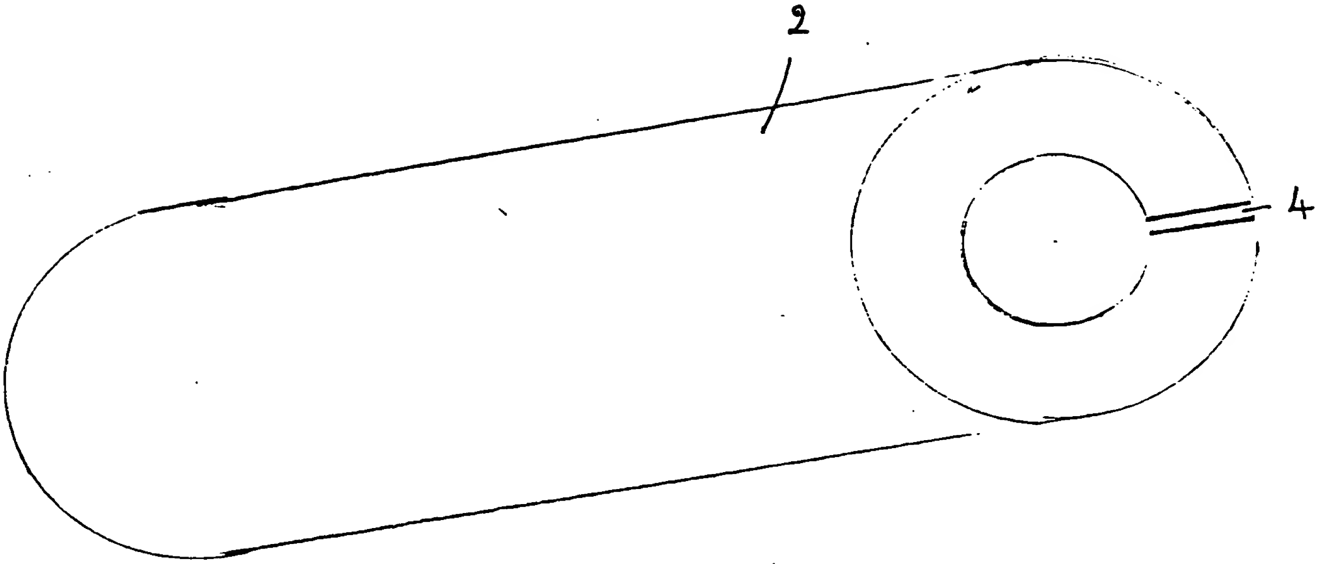

FIGURE 1

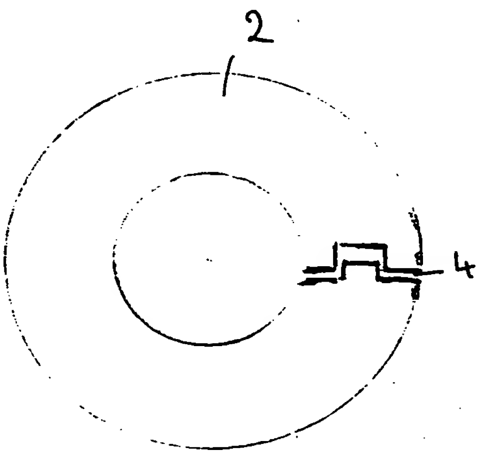

FIGURE 3

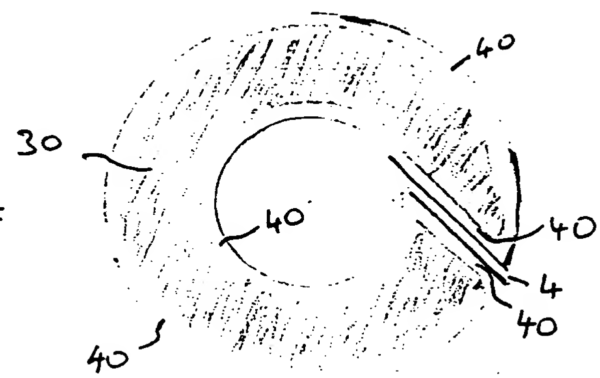

FIGURE 2

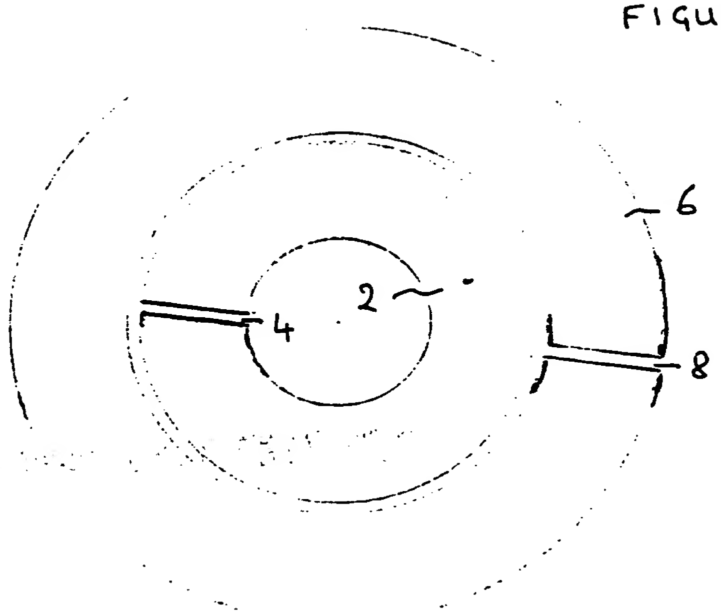

FIGURE 4

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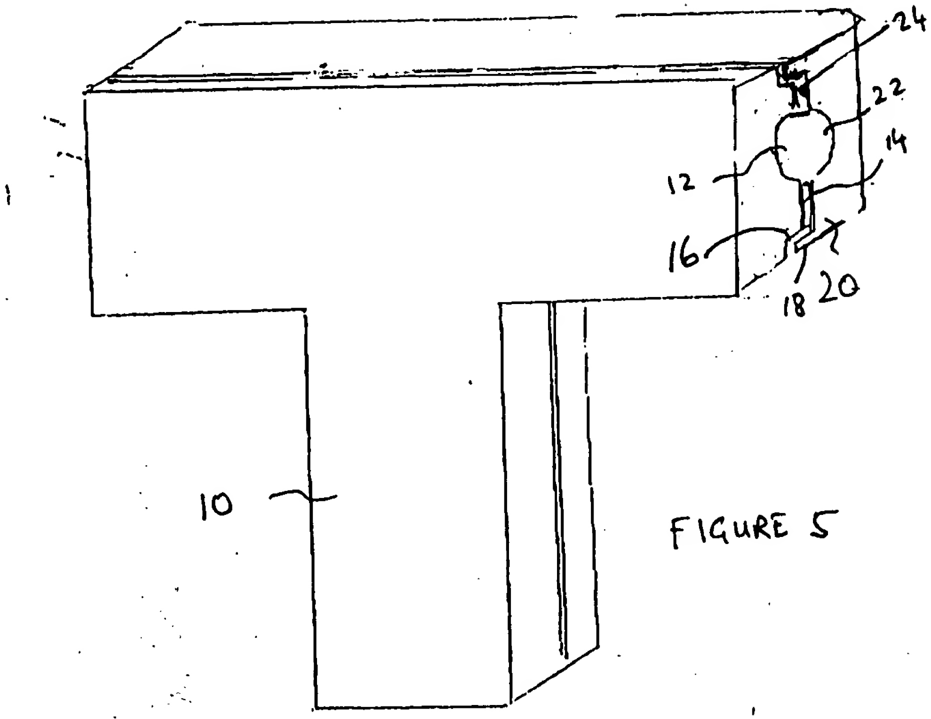
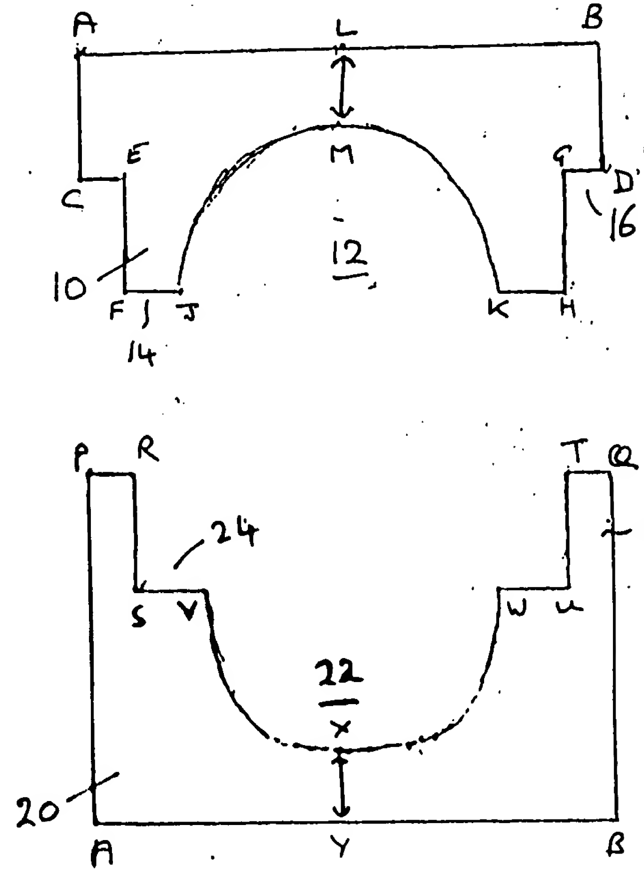


FIGURE 5

FIGURE 6



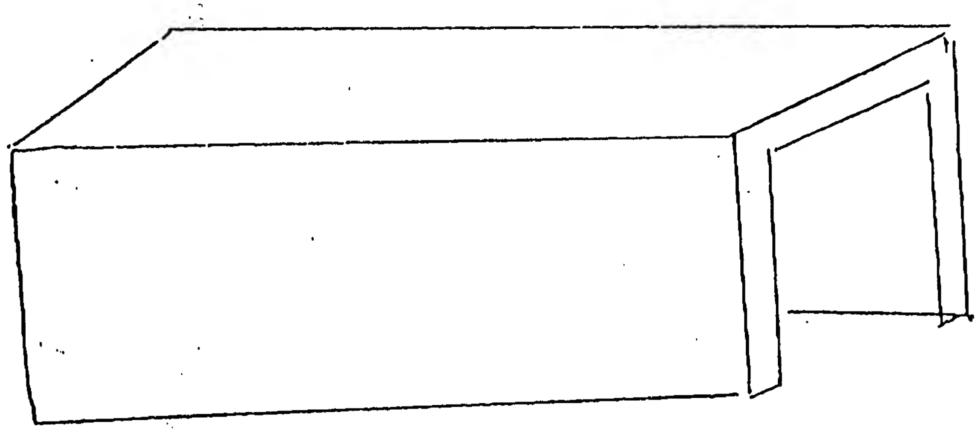


FIG 7